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ABSTRACT

This study of children's memory was intended to: (1) extend a set of procedures used to study levels of processing in the memory of adults, and (2) study the development of the dynamic memory system unencumbered by developmentally influenced strategies in the areas of metamemory, encoding, organization and storage, and retrieval. Ninety-six subjects, 32 each from first, third, and eighth grades, were tested individually for their encoding speeds and recognition memory performance in an incidental learning situation. Subjects listened to a question, read a word that was subsequently presented, and responded "yes" or "no" depending on the fit of the observed word to the question. After 40 trial sequences (10 physical features, 10 rhyming, 10 category, and 10 sentence fit) subjects were given a list of 120 words and were instructed to circle the 40 words that had previously appeared. Results indicated no significant difference in recognition performance by grade. Children recognized words that were processed more deeply (category and sentence fit) better than those processed more peripherally (physical features and rhyme). Encoding time differences were significant by grade, level of process, and original response. (Author/SB)

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Levels of Processing in Children's Memory Development

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The purpose of this study was two-fold: (1) to extend the Craik and Tulving (1975) adult based procedures employed in the study of levels of processing in memory, to the developmentally young, and (2) to study the development of the dynamic memory system unencumbered by developmentally influenced strategies in the areas of metamemory, encoding, organization and storage, and retrieval.

Ninety-six subjects, 32 each from first, third, and eighth grades were tested individually for their encoding speeds and recognition memory performance in a type I incidental learning situation. The subjects listened to a question, read a word that was subsequently presented, and responded "yes" or "no" depending upon the fit of the observed word to the question. The stimulus items were 40 common nouns. The questions were designed to involve the subjects differentially with the stimulus words. After 40 trial sequences 10 physical features, 10 rhyming, 10 category, and 10 sentence fit, the subjects were given a list of 120 words composed of 40 target and 80 distractor words and were instructed to circle the 40 words that had previously appeared.

There was no significant difference in recognition performance by grade, children recognized those words that were processed more deeply (category and sentence fit) better than those processed more peripherally (physical features and rhyme). Those words which subjects responded to as

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"yes" (fitting the question) were recognized better than the words to which they responded "no" (not fitting). Encoding time differences were significant by grade (eighth was fastest while first was slowest), by level of process (sentence fit taking the longest and physical features the longest), and by original reponse ("no" taking longer than yes").

It was concluded that the dynamic memory system is developmentally invariant, as assessed by the tasks in this study, and that this memory system is sensitive to and can be accessed adequately within the levels of processing adult memory framework.

Levels of Processing In Children's Memory Development

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Craik and Tulving (1975) have performed ten studies which have extended the original Craik and Lockhart (1972) levels of processing model of human memory. Five empirical generalizations have emerged from the studies. They are: (1) words that are processed more deeply into the system are remembered significantly better than those processed at a more peripheral level; (2) words that are responded to initially as "fitting" the question ("yes") are remembered significantly better than those that do not "fit" the question ("no"), with the greatest disparity at deeper levels of word processing; (3) encoding times are greatest for those words processed more deeply in the memory system; (4) results are the same for recall and recognition memory; and (5) results hold under both intentional and incidental learning paradigms.

Incidental learning has been employed to gather data in reference to the possible "automatic" nature of the levels of processing function (Murphy and Brown, 1975; Craik and Tulving, 1975). A characteristic of incidental learning is that the subject processes the material in a manner compatible with or determined in part by the particular orienting task in which the subject is involved.

According to Murphy and Brown (1975), Craik and Lockhart (1972), Craik and Tulving (1975), Paivio (1971), Postman (1964), and others, instructions given to a subject to learn may very well facilitate performance, but only insofar as they lead the subject to process the

material in a manner which proves to be more efficient than the processing induced by an orienting task under the incidental learning paradigm. The contention is that intent to learn, per se, has no significant effect on learning. It is the degree to which such an intention prompts processing of the material to be remembered at a deep semantic level that determines the strength and persistence of the memory trace.

Of interest to those who wish to study the development of memory in children is the contention that it is the activity of the subject and not the intent to learn which is important. Adults will often spontaneously adopt appropriate mnemonic strategies (the courses of action which are deliberately instigated for the purpose of remembering) when instructed to learn; they will perform equally well in incidental and intentional situations, both of which induce appropriate mnemonic behavior (Brown, 1974; Flavel, 1970). The general consensus is that the degree to which a deliberate mnemonic strategy is required will determine the extent to which developmentally realted differences in memory performance will occur. The use of cumulative rehearsal (Belmont and Butterfield, 1971; Brown, Campione, Bray and Wilson, 1972; Flavell, 1970), organizational strategies (Tulving, 1962), elaborative strategies (Brown, 1973b; Reese, 1972; Rohwer, 1973), and the strategic non-processing of irrelevant material (Bray, 1973; Hagen, 1972) is strategic behavior which is under voluntary control of sophisticated subjects. As children mature, they gradually acquire such a basic strategy repertoire. They may first acquire strategies by isolated task dependent actions, but gradually these strategies generalize and become much less task specific (Brown, 1973b; Meacham, 1972; Smirnov and Zinchenko, 1969).

Kreutzer, et al., (1975) and Neimark, et al., (1971) have suggested that if strategies for acquisition of information are inadequate in the developmentally young, strategies for retrieval of processed information will be also. Developmental differences would be expected to the extent that any given task demands strategy sophistication in either acquisition or retrieval, or both.

For the present study it was assumed that the questions used in Experiments I and II (Craik and Tulving, 1975) constituted a maximally favorable mnemonic strategy as indicated by the lack of memory difference in adult subjects in intentional and incidental tasks. Adult subjects, while capable of employing specific mnemonic strategies, did not do so for two possible reasons: first, the intertrial intervals were too short to allow ample time to employ a subjective strategy; or second, the experimenter-induced mnemonics (via questions) proved to be more favorable for the specific tasks than were the subjective mnemonics. It has been suggested by Brown (1973a and c), Brown, Campione and Gilliard (1974), and Neimark, Slotnick and Ulrich (1971), among others, that an age effect is found in memory tasks only when the tasks are such that performance can be facilitated by the deliberate employment of mnemonic strategies.

The present study was designed to extend Experiments I and II (Craik and Tulving, 1975) to the study of memory in a younger, less sophisticated population. Further, the study was designed to explore memory development unencumbered by developmentally influenced strategies at encoding and retrieval. The procedure employed both incidental learning and recognition memory. For the present study it was assumed that this procedure would bypass the switching-in of subjective mnemonic strategies at encoding, and recognition memory would eliminate the need for a

retrieval strategy (Kintsch, 1970), both of which have been shown to be developmentally influenced.

It was assumed, after Brown (1975), that the memory system can be divided into three parts: knowing, knowing about knowing, and knowing how to know. Knowing is the dynamic knowledge system, semantic memory which underlies all cognitive activity. Knowing about knowing refers to metamemorial processes or the knowledge gained by the introspective process concerning the functioning of one's own memory processes. Knowing how to know is indicative of the repertoire of strategies and skills one possesses for deliberate memorization activities: the tailoring of specific mnemonics to meet task demands. The notion then is since the incidental learning paradigm by its very nature bypasses the switching-in of deliberate mnemonic strategies (knowing how to know), and the use of recognition memory bypasses deliberate retrieval strategies (Kintsch, 1970), that if any age-related differences were observed, they would be products of differences in the dynamic memory store rather than strategy deficits.

Method

Subjects

The Ss were 32 each first, third and eighth graders, 48 males and 48 females, attending elementary and middle school in Albuquerque, New Mexico. The first graders had a mean age of 6-years, 7-months, the third graders had a mean age of 8-years, 9-months, the eighth graders had a mean age of 13-years, 7-months. The subjects were randomly assigned to the experimental conditions from a pool of approximately 80 students from each grade. The socio-economic status of the majority

of the students used was upper-middle class. Further, a review of the teacher ratings showed that the majority of students used in the study were above average in reading achievement.

Materials

The stimulus words are presented in Table 1. Each word was chosen and screened for applicability for the youngest students. It was determined where the first graders were in their reading textbooks and then a pool was drawn from this source. Since the word pool for presentation and recognition was the same across the three grades, it was felt that screening for applicability at the lowest grade in turn fulfilled the obligation at the two remaining grades.

Since one-fourth of the questions in the experiment were sentence-fit questions, a process was employed similar to the word screening process to develop sentences which younger Ss were able to understand.

The 40 nouns were presented via a Caramate slide/tape projector, which was programmed to advance the tray at specific intervals. Two keys were used to record the responses of the Ss. The keys were marked "yes" and "no." The two keys were connected to a Lafayette Digital Multi-Choice Reaction Timer. The timer was started on the pulse that advanced the slide to the screen and was subsequently stopped when the subject responded by closing either switch. The individual responses were monitored for time by the timer read-out and for specific response by the illumination of color coded lights. The questions were recorded on cassette tapes which were compatible with the slide/tape unit.

For the encoding phase of the experiment, 40 words were used, one for each question/word trial. Five words were represented in each of

the eight conditions (4 levels x yes-no). The same pool was used for all 96 subjects, but each word was rotated through the eight combinations so that, for different subjects, a word was presented as a category-yes stimulus, a rhyme-no stimulus, and so on. This procedure yielded eight combinations of questions and words; four Ss were randomly assigned to each combination at each grade level. The eight combinations of questions and words were governed by eight different cassette tapes and four different word orders. Each tape was comprised of the same introduction and instructions, but different in word/category question sequences. There were four different word orders, two conditions in each; therefore, four word slide trays were used.

The recognition test sheet is presented in Table 2; it is comprised of the 40 original words from the encoding phase and 80 distractor words drawn from the same word pool.

Procedure

To familiarize the Ss with the procedure, each received four pretraining trials, one from each category in the encoding phase. The pretraining was conducted using 3 x 5 white index cards with one word printed on each card. The words, although drawn from a common pool, were used only in the pretraining phase. This phase had at least four question-word-response trials, but did not exceed eight. If after eight pretraining trials an individual S was still uncertain of the procedure, then he was eliminated from the study. Only two first graders were eliminated from the study and none from the other two grades.

After the Ss had received pretraining, they were administered both the encoding and recognition phases. The Ss were seated at a small table,

were instructed to put on their set of earphones, to push the "yes" and "no" keys at their front, and to watch the screen very carefully. All subjects received the same taped instructions regardless of sequence. The Ss were instructed to listen to the tape, read the words that came on the screen, and respond by pushing either the "yes" or "no" key.

In the encoding phase of the experiment all Ss received 40 trials. Four types of questions were used. Type I (level 1) asked about the physical features of the word displayed. Type II (level 2) asked if the to-be-displayed word rhymed with a given target word. Type III (level 3) asked categorical questions about the to-be-displayed word. Type IV (level 4) asked only sentence-fit questions. A sentence was presented aurally with a word missing--the to-be-displayed word either fit the blank or did not. As an example, the first level asked, "Is the word that you are going to see printed all in the same sized letters?" The second, "Does the word that you are going to see rhyme with _____?" The third, "Is the word that you are going to see an animal?" The fourth, "Does the word that you are going to see fit this sentence, 'The man drove the _____'?"

The questions were presented twice to each S. After question offset, one second elapsed and a word appeared on the screen for approximately ten seconds. It was within this ten second time frame that the S responded and the response time and type ("yes," "no") were recorded by the E on the tally sheet. There was an additional two-second delay between the offset of the slide and the start of a new question for the next trial.

After the last response in the encoding phase, each S was presented with the recognition sheet and was told to circle with a pencil

those words that were seen on the screen in the first part of the game. Each S was told that he could take as much time as he wished, to be very careful and, further, that when he was through he should have 40 words circled.

Results

Deletion errors in the recognition phase, categorized by their positions in the encoding phase and by the responses made to the words in the encoding phase were analyzed. The deletion errors were tallied for each S given the tape/slide presentation in which he/she participated. The errors were tallied to indicate at which level the words were encoded, and whether the S had responded initially "yes" or "no." Response times from the encoding phase, by levels 1-4, by response "yes" and "no," and by grades 1-3-8 were also analyzed.

Multivariate Analysis of Errors and Encoding Times

A split plot multivariate analysis of variance was performed on the data. The results are presented on Table 3. There are five significant theta maximum values. The first value by source grade is a product of the strength of the variable encoding times, as are the two significant interactions. The remaining two significant theta values are products of the shared strength of both the dependent measures of errors and encoding times, by level and response.

Two split plot univariate analyses of variance were subsequently performed to enhance data presentation and elaboration. The univariate

analysis F-ratios were checked for significance by the F-maximum procedure (Harris, 1975). This procedure takes the critical theta value by source from the multivariate table and converts it to an F-value which is not only more stringent than the Geisser-Greenhouse conservative F-test (1958), but is by its nature a logical extension of the control generated by employing the multivariate analysis of variance.

Analysis of Deletion Errors

A 3 x 4 x 2 split-plot analysis of variance was performed on the natural log transformations of errors in terms of level, age, and response. The analysis revealed that there was no difference in recognition performance by grade ($F = .54$, $df = 2/93$, $p > .01$). The main effect of levels was significant ($F = 279.56$, $df = 3/279$, $p < .01$). A Scheffé (S method) comparison showed that recognition performance was greater for those words processed at levels 3 and 4 ($F = 54.37$, $p < .01$). The main effect of initial response was also significant for those at levels 1 and 2 ($F = 18.19$, $df = 1/93$, $p < .01$), indicating that those words initially responded to as "yes" are recognized better than are "no" words. The grade x level interaction was not significant ($F = 1.4038$, $df = 6/27$, $p > .01$), suggesting that the levels effect was constant across the sampled ages.

A P-analysis (Rosenthal and Rosnow, 1975) was conducted on the significant errors F-ration at levels 1-4, which indicated that 71% of the variance in errors was attributable to the levels effect. A P-analysis was conducted for the significant response F-ratio which indicated that 12% of the variance in errors was attributable to the initial response made to the stimulus items by each S.

Figure 1 depicts the performance of subjects by grade, by level and by initial response on the recognition task. The ordinate reflects total untransformed means by grade. It can be seen that while there is no difference in overall performance by grade, there are observable differences by levels and initial responses.

Analysis of Encoding Times

A 3 x 4 x 2 split-plot analysis of variance was performed on the square root transformations of encoding times in terms of level, age and response. The analysis revealed a significant F-ratio for the main effect of grade ($F = 136.70$, $df = 2/93$, $p < .01$). A Scheffé comparison procedure showed that the eighth graders encoded faster than the other two groups combined ($F = 27.01$, $p < .01$). The main effect of levels also was significant ($F = 102.69$, $df = 3/279$, $p < .01$). A Scheffé comparison procedure showed encoding times were longer at levels 3 and 4 than at levels 1 and 2 ($F = 19.20$, $p < .01$), with the greatest difference between levels 1 and 4 ($F = 31.47$, $p < .01$). The main effect of response also was significant ($F = 97.39$, $df = 1/93$, $p < .01$); "yes" responses were encoded more quickly than "no" responses. The grade x level interaction was not significant ($F = 3.48$, $df = 6/279$, $p > .01$), suggesting that the levels of processing effect was temporally constant across the sampled ages. The levels x responses interaction was significant ($F = 63.90$, $df = 3/279$, $p < .01$). This interaction can be seen in Figure 2. A Scheffé comparison showed that as encoding progresses from level 1 to 4 "no" encoding times become progressively longer than "yes" ($F = 17.38$, $p < .01$). The grade x level x response interaction was significant ($F = 12.39$, $df = 6/279$, $p < .01$). This

interaction can be seen in Figure 3. A Scheffe comparison showed that increased times of "no" with increased levels is greater for younger children than older children ($F = 18.37$, $p < .01$).

P-analyses were calculated on all significant F-ratios generated by the split-plot analysis of variance. The three significant main effects, grade, levels and response, account for 31%, 28% and 15% of the variance in encoding times respectively. The significant first order interaction levels x response accounts for 9% of the variance in encoding times. The significant second order interaction grade x level x response accounts for 2% of the variance in encoding times. On inspection it can be seen that only 15% of the variance remains unaccounted for, which would indicate that there is a high probability that the observed performances were influenced substantially by the independent variables.

Discussion

The results of this study extend the levels of processing effects noted by Craik and Tulving (1975) with adult subjects to children as young as first graders. These results replicate in part Jenkins' (1973) finding of superior memory performance following comprehension instructions as compared to tasks requiring only formal orienting behavior. Material processed to a level of semantic encoding is more durable than material subjected to a more superficial analysis at the level of physical features (Craik and Lockhart, 1972; Craik and Tulving, 1975). Yussen, Levin, DeRose and Ghatala (1975) found better memory performance by first and second grade children who processed stimulus items semantically rather than physically.

Memory in children, as in adults, is a function of the depth of comprehension in initial encoding. If a task requires that the subject consider the meaning of the stimulus items, memory performance will be enhanced regardless of age. Since there was no significant grade x level interaction, it can be assumed that the effects of levels of processing are invariant across the ages sampled in this study. Furthermore, the intent to learn by itself may not be the most important factor in memory performance, for performance depends on the degree to which the task induces appropriate mnemonic activities by the subject. Here the incidental learning paradigm, since it does not signal learning for future memory performance, bypasses the automatic switching-in of task specific strategies and, thus, allows the inducement of experimenter-designed mnemonics which would then not interfere with the subjective mnemonics. This incidental procedure is useful in that young children have difficulty with the intent to learn as a goal in itself, rather than as a means for achieving memory performance at some later time (Yendovitskaya, 1971).

The present results found the same separability of "yes" and "no" responses in children as was reported with adults. It is tempting to explain this response dichotomy in keeping with those explanations presented by the authors. Note, however, that while the children's performances parallel those of adult subjects, they may not have the quantity of semantic memorial attributes that adults possess. This explanation logically follows the statement that memory performance cannot be considered to be simply a function of the quantity of encoded attributes; rather, the qualitative nature of these attributes is the

critically important factor (Craik and Tulving, 1975). The children in this study had sufficient qualitative semantic attributes to function as adults in encoding the to-be-remembered words.

Craik and Tulving (1975) found that they could produce the levels effect by asking questions of the to-be-remembered words under instructions to learn or under the incidental paradigm. Incidental learning in children, in the sense of executing a plan without intent to memorize, rarely has been studied by American psychologists; the Soviet psychologist Zinchenko (Smirnov and Zichenko, 1969) has conducted several relevant studies as have Murphy and Brown (1975) in America. These studies indicate that pre-school children can freely recall pictures that were encoded semantically quite accurately under the incidental paradigm.

Corsini, Jacobus and Leonard (1969), and Brown and Scott (1971) employed recognition memory, which largely bypasses retrieval (Kintsch, 1970), and found no age differences in children as young as 5-years old in recognition performance for pictures. Brown (1973b), employing a judgment-of-recency task with a list of words, found no differences in task performance in ages 7-18 years. Brown, Campione and Gilliard (1974) suggested that an age effect in memory will be found only when the task is such that performance could be facilitated by the deliberate use of a strategy.

No research on memory development has yet to employ both incidental learning and recognition memory together to study the development of memory for words. This study was designed not only to bypass strategies at encoding, but to eliminate retrieval strategies as well in an attempt to study the development of the dynamic memory system.

The non-significant effect of grade on recognition performance would lend support for past research that has been designed to show that memory development is the development of strategies for getting information into and out of the memory system. Since controls were employed to bypass developmentally influenced strategies at input and output in this study, it is suggested that the dynamic memory system is invariant within the sampled ages and within the task demands.

Although there were no differences in recognition performance by grade, there were significant differences in encoding times by grade. The differences in encoding times may be explained by differential reading times, with the first graders reading somewhat slower than the third graders and still slower than the eighth graders. These differences also may reflect that the younger subjects spend more time on target, not as a function of reading speed but because they wished more time to rehearse the to-be-remembered words, which certainly could jeopardize the conclusions drawn in reference to the memory invariance. If the younger subjects did make use of a rehearsal strategy during their longer time on target than their older counterparts, then the equality in performance in the recognition phase would not be attributable to memory invariance but to differential rehearsal strategies. Since incidental learning does not cue the subject as to his future requirements, it is suggested that no deliberate strategy was employed and certainly not for one group over another, but that the differences in encoding times by grade reflect only differential reading speeds.

It is interesting to note that the two additional findings of encoding time differences at levels of processing and initial responses

("yes"-"no") replicate those of Craik and Tulving (1975). These encoding time differences suggest that the children in this study found that it took more time to make a negative decision than a positive one. If positive instances are brought to bear on the questions by the subjects, then it would seem logical to assume that it would take less time to confirm the positive than to disconfirm, since in confirmation only one of the positive attributes would have to coincide. The entire array of instances would have to be exhausted for a disconfirmation.

This study, through the process of inducing involvement with to-be-remembered information under incidental learning and through employment of a recognition memory task, supports the contention that previously observed differences in memory performance by age may be an artifact of developmentally influenced strategies at input and/or output.

The encoding time data at levels and responses support further the applicability of the levels approach for the developmentally young, since these data replicate those generated by adults. The differences in encoding times noted by grade are thought to reflect only reading speed differences.

TABLE 1

STIMULUS WORDS USED IN ENCODING

1.	Hair	21.	Carrot
2.	Daisy	22.	Hand
3.	Broom	23.	Trumpet
4.	Snow	24.	Peach
5.	Food	25.	Pepper
6.	Apple	26.	Glass
7.	Cloud	27.	Kitten
8.	Club	28.	Ball
9.	Nest	29.	Desk
10.	Cherry	30.	Bear
11.	Coke	31.	Card
12.	Candy	32.	Meat
13.	Wing	33.	Light
14.	Socks	34.	Milk
15.	Party	35.	Floor
16.	Cheese	36.	Clock
17.	Bean	37.	Mouse
18.	Bike	38.	Rain
19.	Button	39.	Rose
20.	Doll	40.	Chip

TABLE 2

RECOGNITION TEST SHEET

SNOW	HAIR	COAT	BABY
FOOD	GAME	CHERRY	PAGE
BABOON	BALLOON	CIRCLE	BIKE
CLUB	DAISY	BOOK	GRASS
BUTTON	STORE	NEST	BACK
CLOUD	CROSS	BIRD	COKE
APPLE	BROOM	CRAYON	BED
PANTS	FEATHER	WING	MOON
ORANGE	BLOCK	MORNING	PARTY
SOCKS	CLAW	DIME	CAP
DIRT	CUP	POP	HAT
BEAN	CHEESE	BOTTLE	DOOR
DRUM	PAINT	DOLL	PLUG
PAPER	HAND	PLANT	LEAF
CARROT	POT	WOOL	BAT
TRUCK	TRUMPET	FINGER	PEACH
COIN	GLOVE	CALF	EAR
PEPPER	SHIRT	BALL	AUTO
GLASS	SHOE	DESK	EYE
FISH	KITTEN	BLACK	MEAT
HOUSE	DOG	CHAIR	SQUARE
BEAR	NOSE	BROWN	DART
BOWL	CARD	FOOT	LIGHT
WHITE	BOX	FLOOR	HORSE
PICTURE	BOAT	LEMON	MILK
CLOCK	MOUSE	RUG	HEART
BUSH	CELLAR	PIANO	HORN
RAIN	SUN	BULB	CAT
BUN	PLANE	CITY	YELLOW
BLUE	ROSE	CANDY	CHIP

TABLE 3

MULTIVARIATE ANALYSIS OF VARIANCE
(Encoding Times and Deletion Errors)

	Source	Lambda max	Theta max	s	m	n	Theta Critical (.01)
1	Between						
2	Grade (A)	2.97	.74*	2	0.5	45	.12
3	Subjects W/in Groups						
4	W/in Subjects						
5	Levels (B)	3.46	.77*	2	0	138	.12
6	A x B	.07	.07	2	1.5	138	.08
7	B x Subjects W/in Groups						
8	Response (C)	1.13	.53*	1	0	45	.17
9	A x C	.06	.05	2	-.5	45	.10
10	C x Subjects W/in Groups						
11	B x C	.69	.40*	2	1.5	138	.08
12	A x B x C	.28	.21*	2	1.5	138	.08
13	BC x Subjects W/in Groups						

*$p < .01$

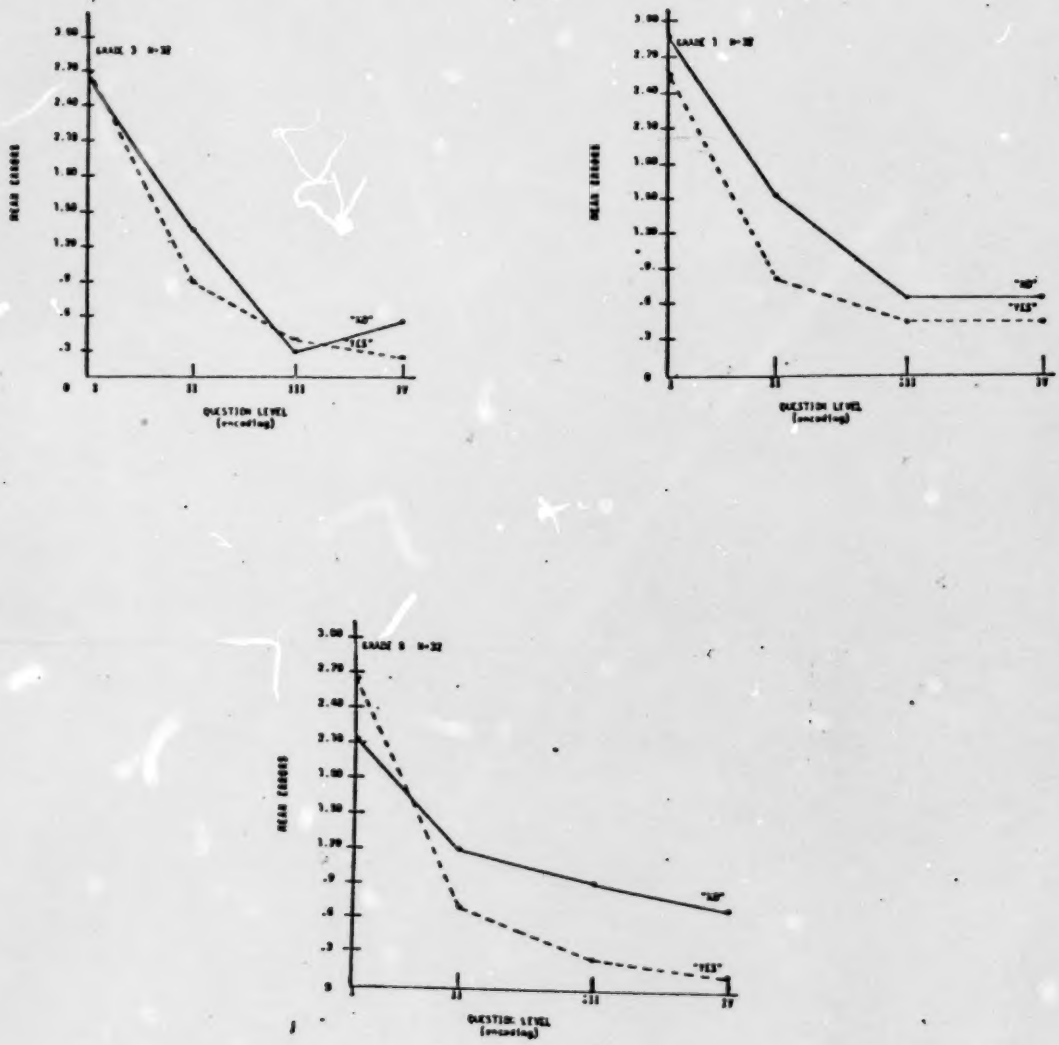

Figure 1. Mean Deletion Errors in Recognition (Original Response)

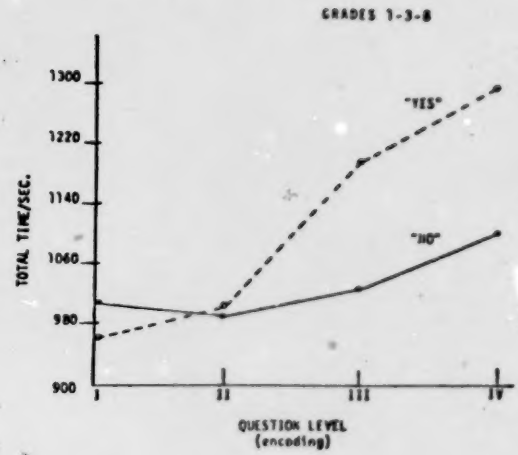

Figure 2. Total Response Times in Seconds (Combined Grades)

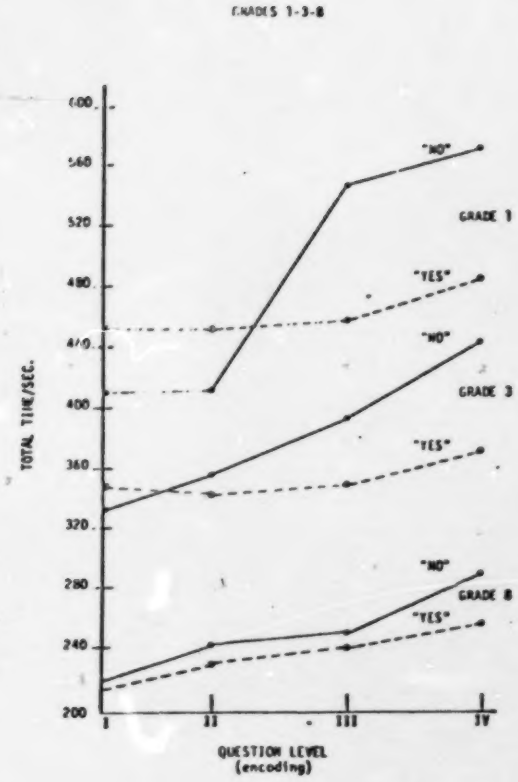

Figure 3. Response Times in Seconds (Original Response)

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